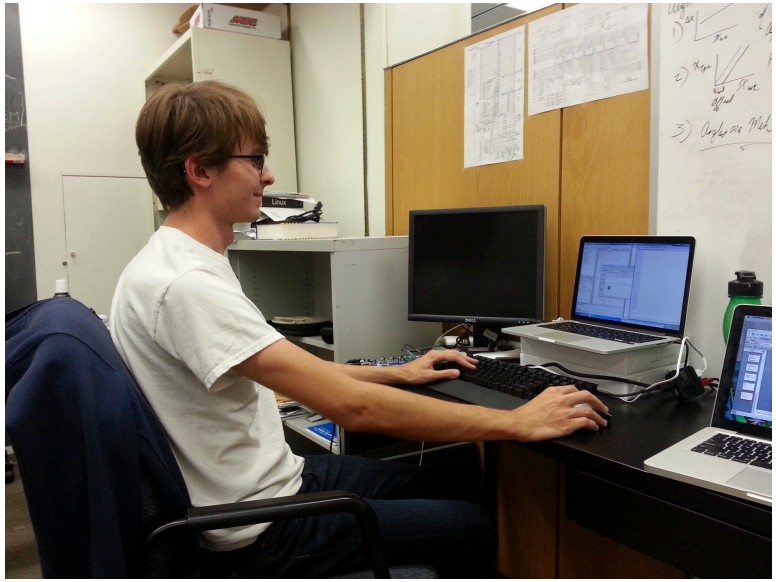
BOSTON UNIVERSITY

Observation of d = vt in the LArIAT TOF System



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Lariat Post-Equinox Summit

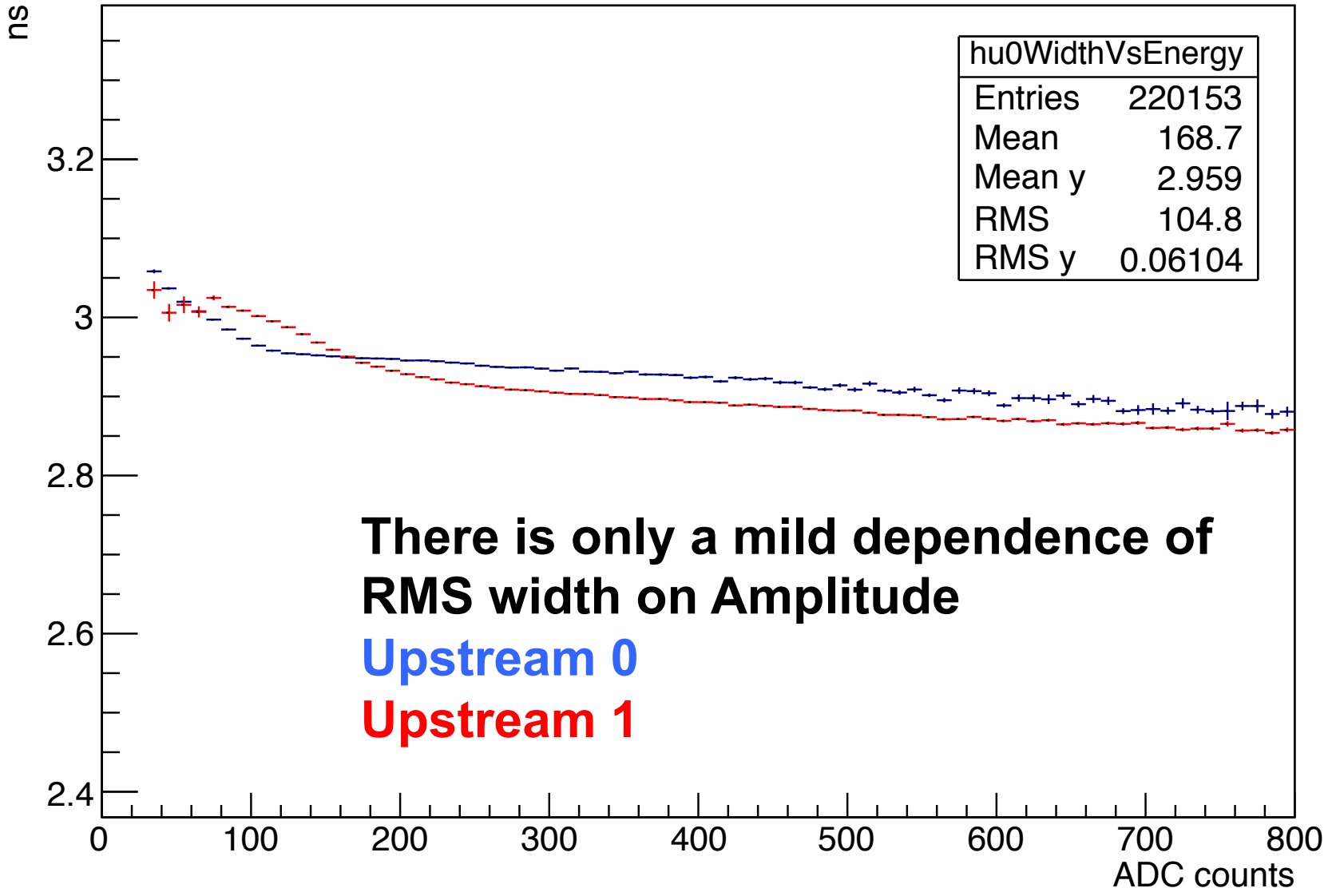
Previous Presentation: Template fitting

- If the shape of the pulse is consistent (significant variations in amplitude and offset only), we can use that shape to improve the timing resolution considerably. In BNL E821, we sampled our SCI-FI calorimeter pulses every 2.5 ns but achieved 60 ps resolution. It helps to have limited optical paths and a lot of light!

Muon g-2 pulse fitter: V. Logashenko

- **Find a statistic which characterizes the relative phase of the sampling and the peak of the pulse**

Upstream Scintillators: Width Profile vs. Amplitude



Determining true pulse maximum within the bin

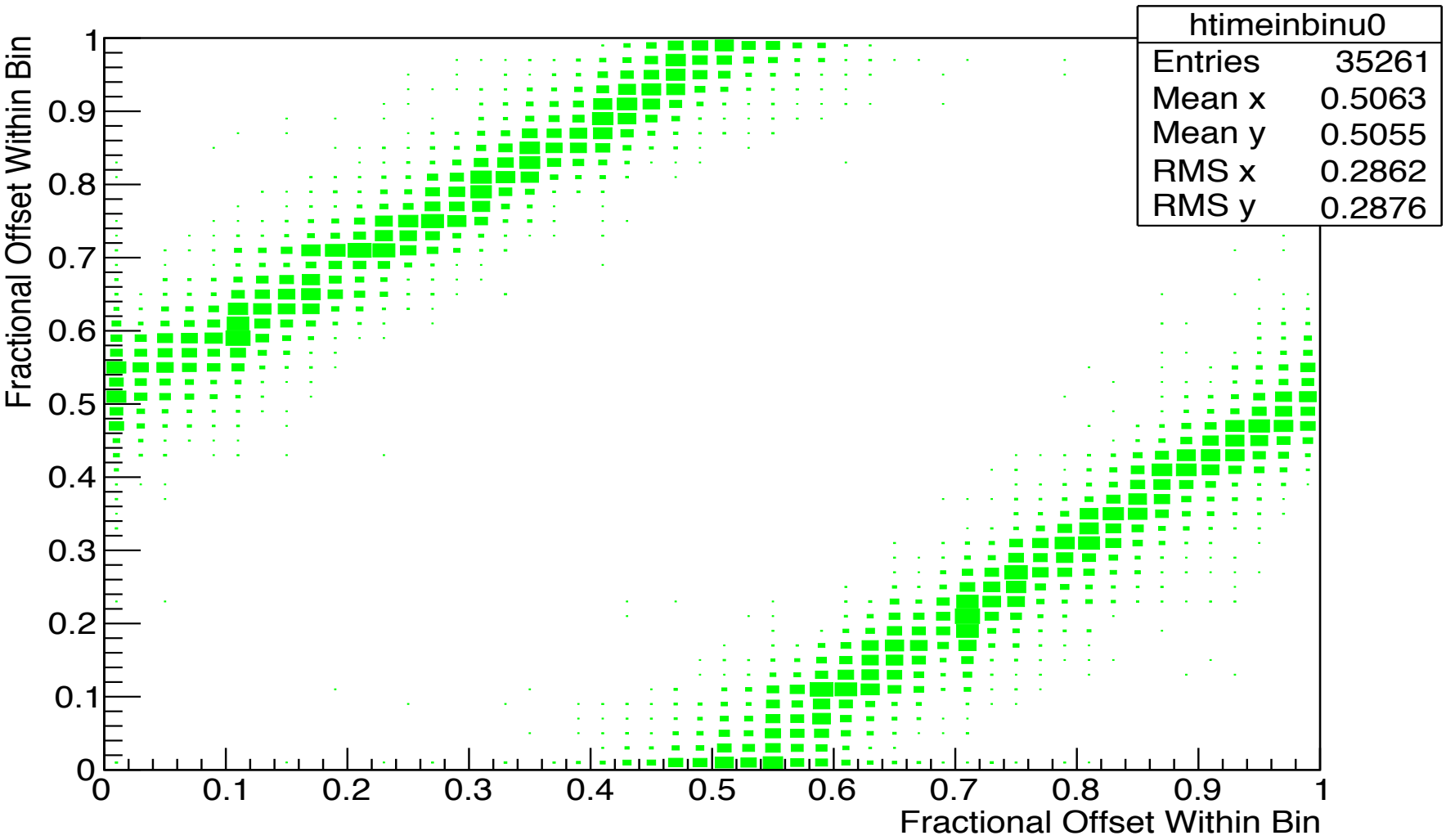
Define the pseudotime:

$\psi = T * (2/\pi)\ \mathrm{atan}\ ((MAX-PREV)/(MAX-NEXT))$

where

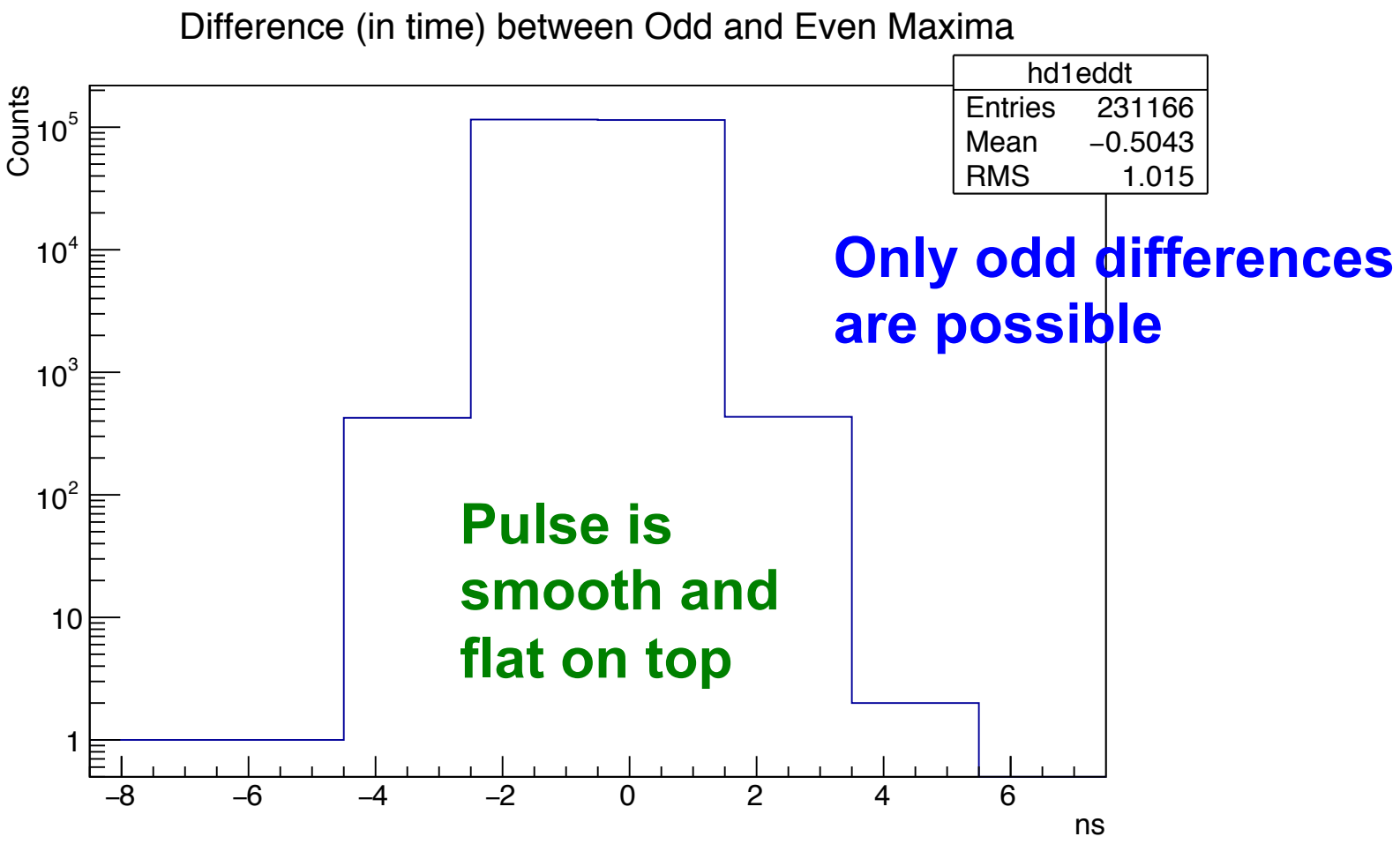
1. T: sampling period
2. MAX: maximum sample
3. PREV: sample preceding MAX
4. NEXT: sample following MAX

The pseudotime tells us how we caught the pulse : sampling phase



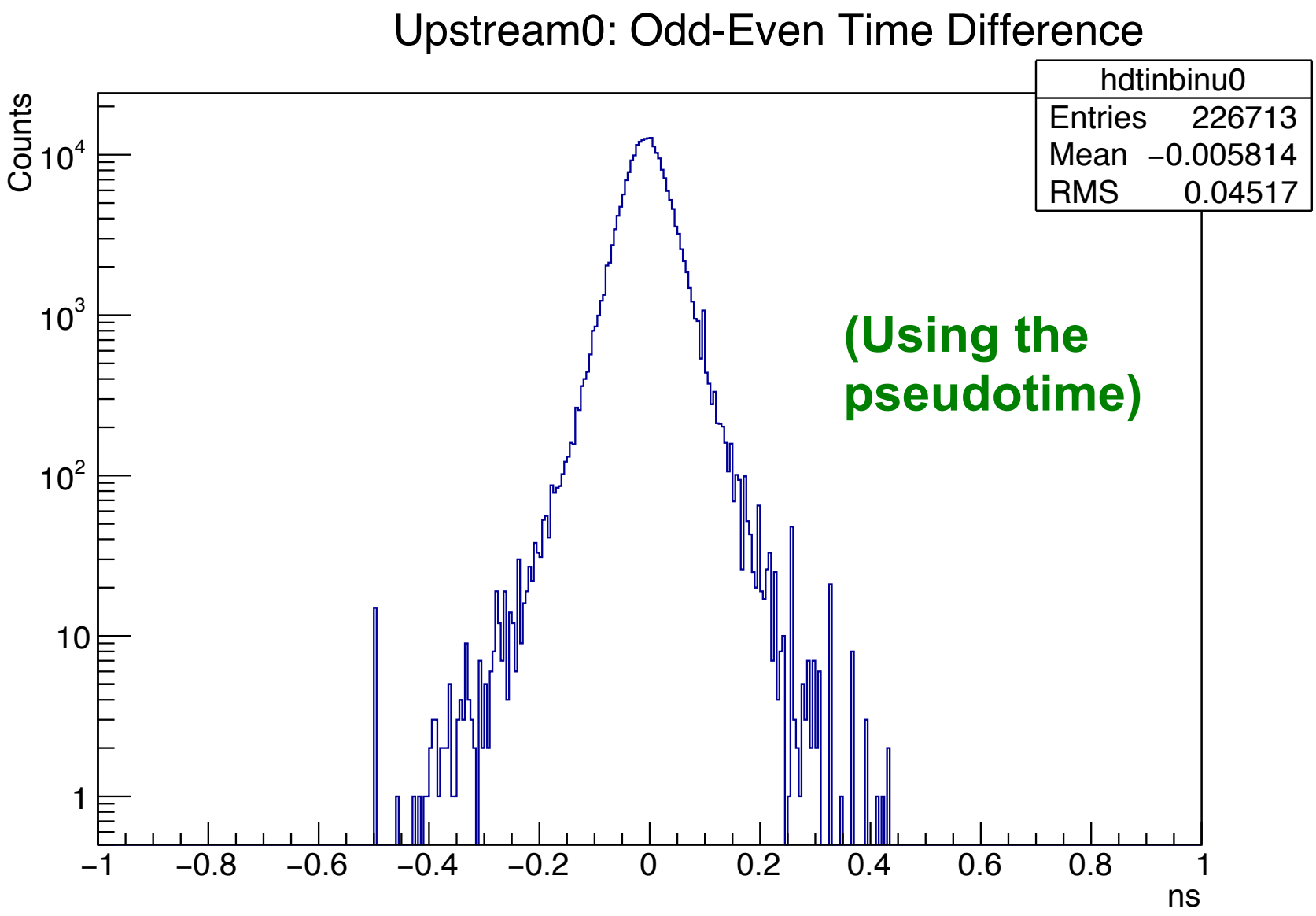
LArIAT TOF sampling is so dense that we can define two pseudotimes (odds and evens) and determine a time from each

How do the odd- and even sample views of the pulse compare? Do they agree?



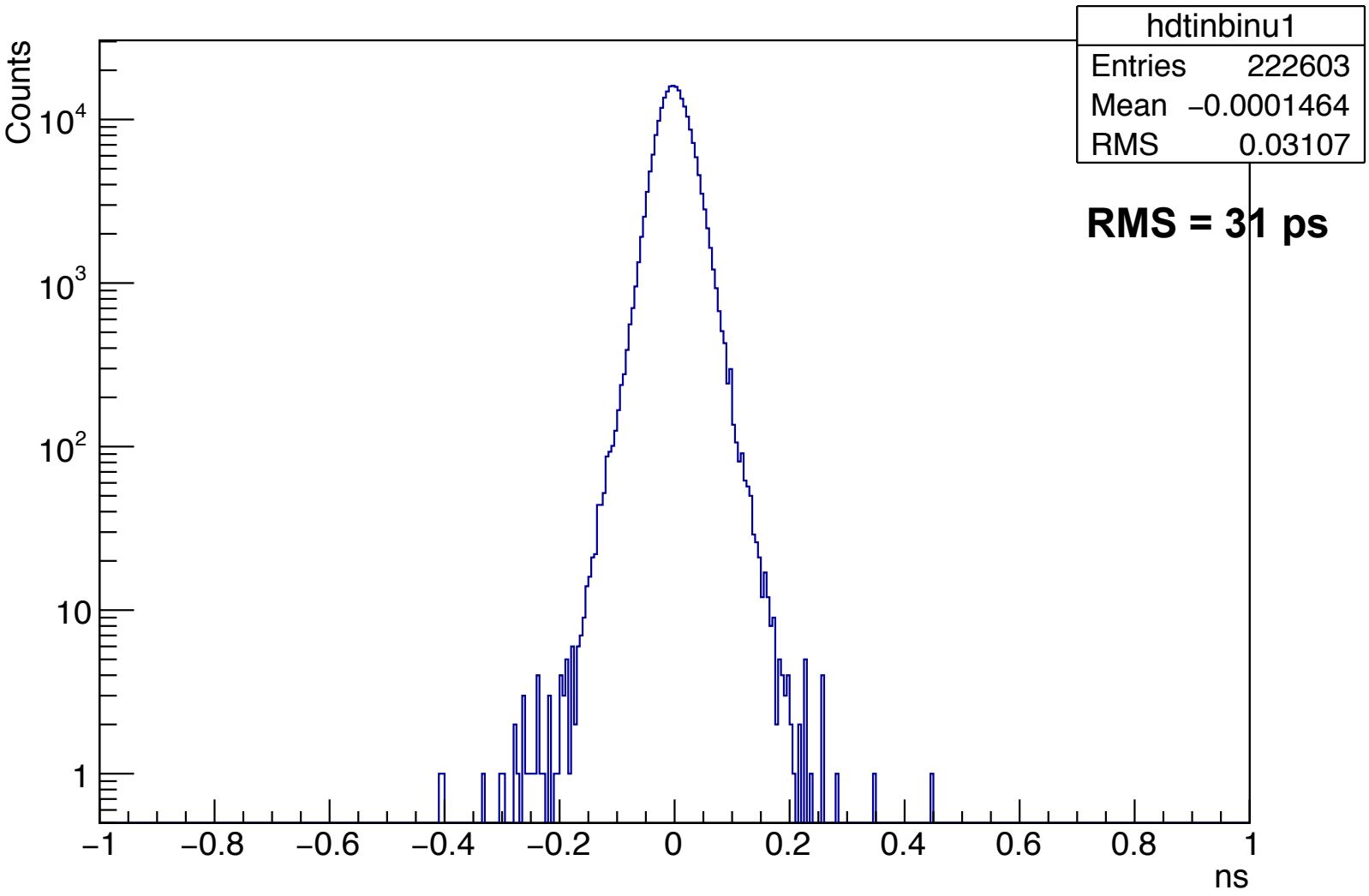
Maybe not so badly

- Difference between odd and even maxima should usually be 1 or -1 (It is)
- If something funky is going on at flattop, that difference might be 3 or -3 (Yes, but down by two orders of magnitude)
- Not much else going on



The two views agree nicely for Upstream Counter 0

Upstream1: Odd-Even Time Difference

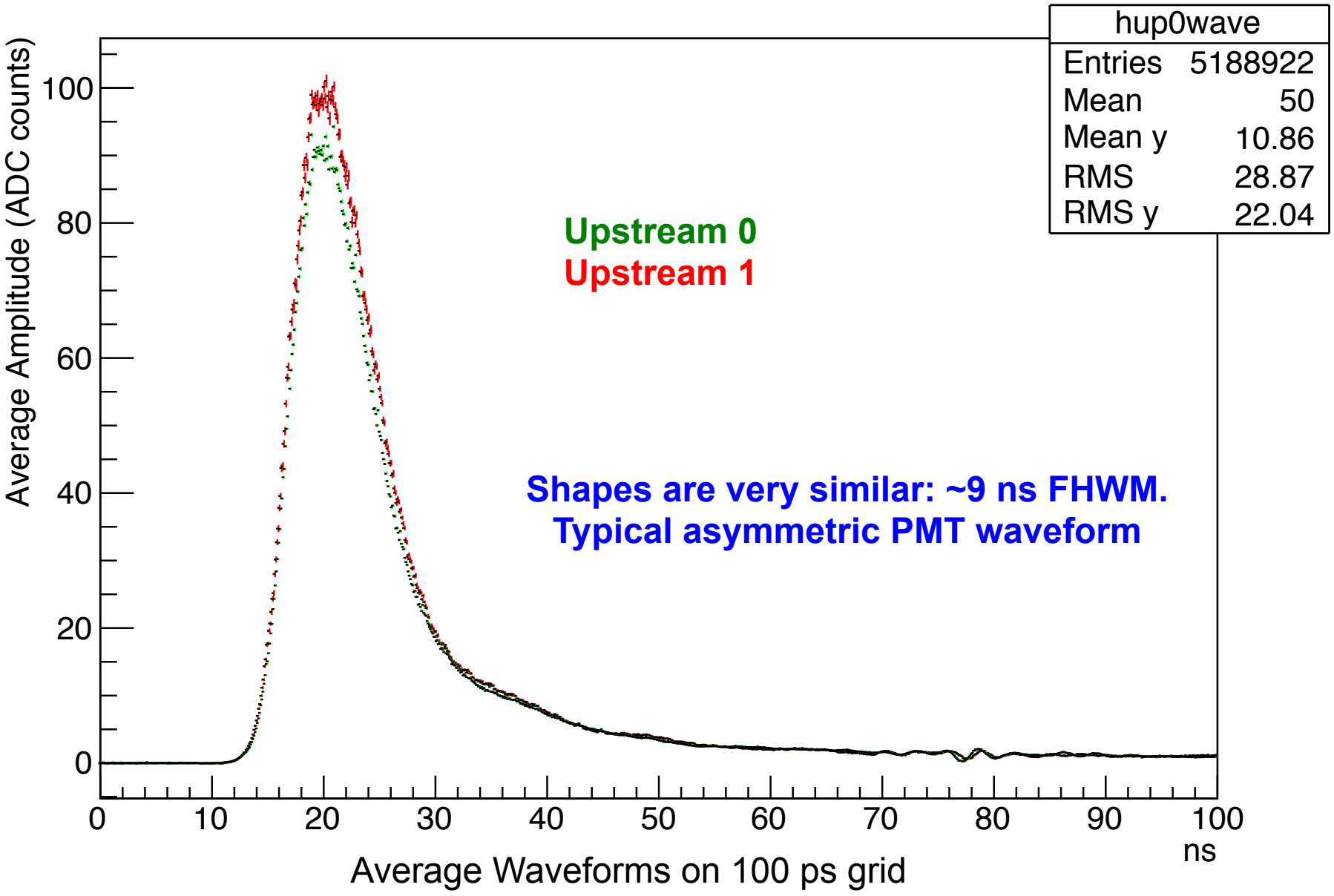


Odd and Even views also agree for Upstream Counter 1

We can make the connection more precise and more useful

- ψ is a proxy for the time-within-the-time-bin
- ψ changes monotonically with sampling phase
- If the pulses arrive at random times WRT to the sampling clock, we can immediately construct a mapping $\mathcal{M}$ from pseudotime to "time-within-the-time-bin"
- With the assumption of random arrival and armed with $\mathcal{M}$, we can construct the average pulse shape

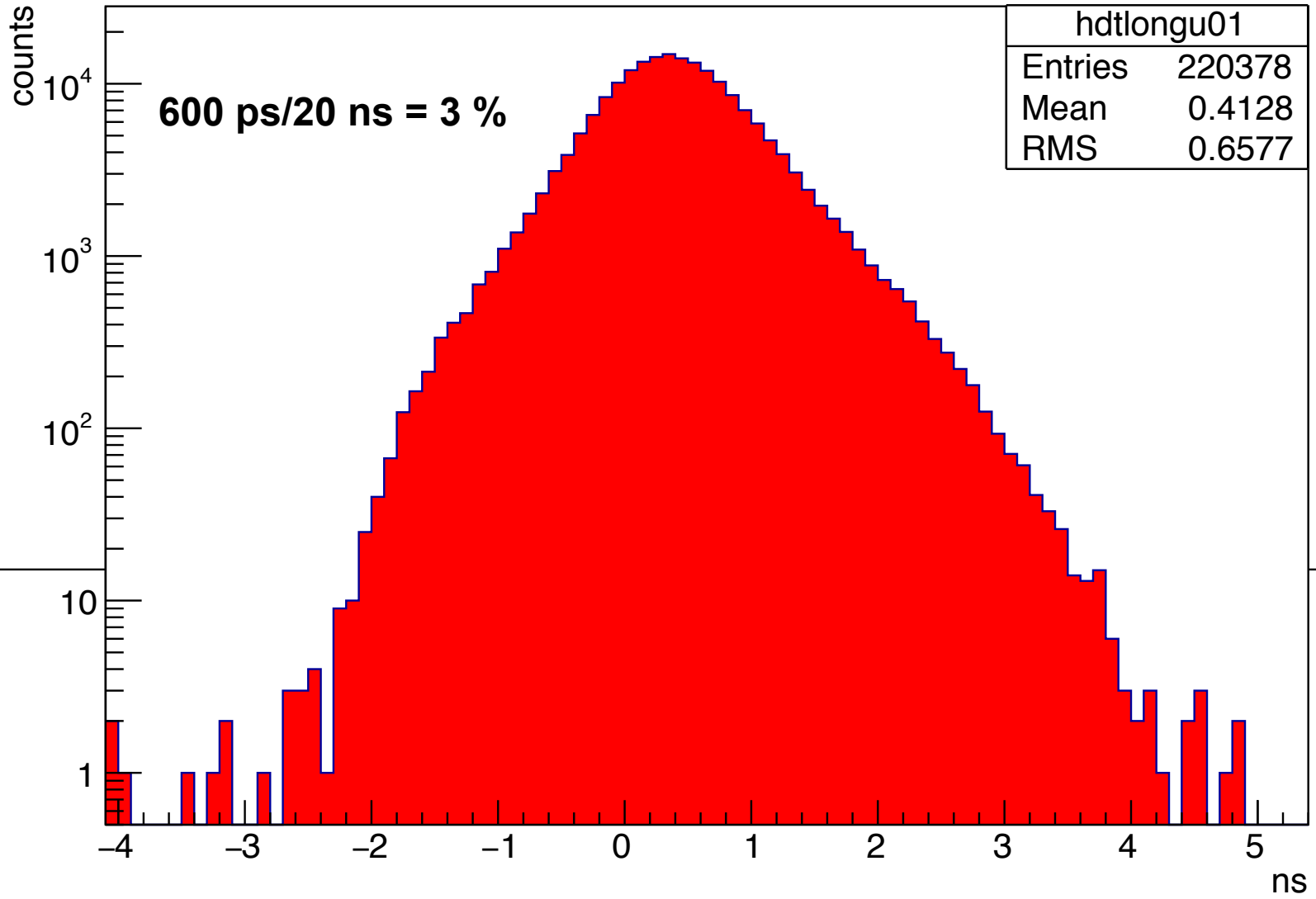
Upstream Waveforms



So far, our template fitting has been an interesting academic exercise…

- Do upstream 0 and upstream 1 agree on the time?
- If not, why not?

Upstream Counter Time Difference



There's more to good timing than waveform analysis

Taking a Closer Look

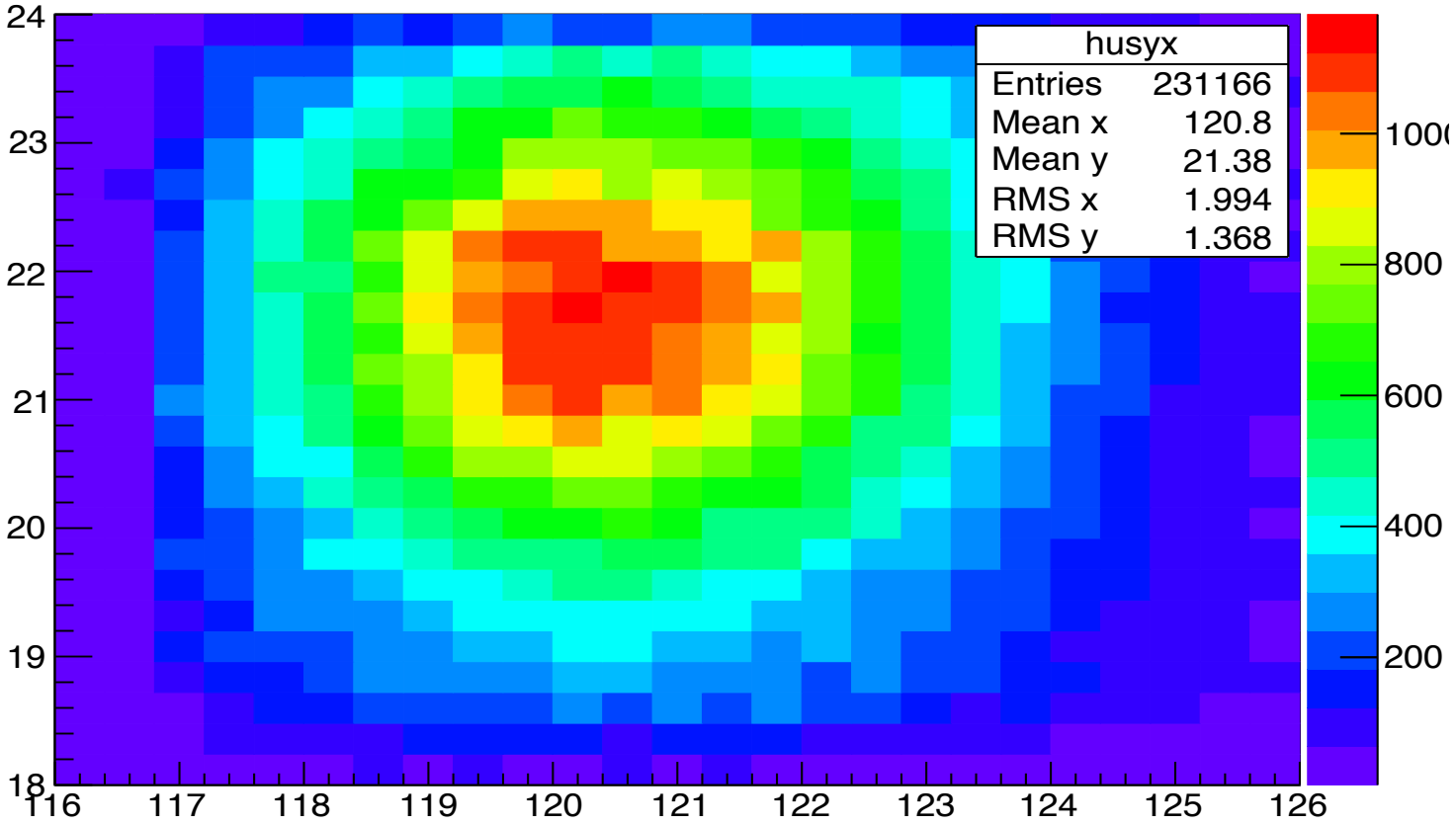
- Upstream Scintillator is pretty big and PMTs 0 and 1 are far apart.
- Scintillator is 15 cm x 15 cm x 5.08 cm (lariat.gdml) and sits ~ 30 cm from first MWPC
- That said, there are lots of dts as large as a couple of ns – even in scintillator, light travels ~20 cm/ns
- JMStJ: use tracking chambers to find impact point on scintillators (for Picky Tracks)
- Start with Upstream Scintillator: PMTs 0 and 1

Dan leaps into action!

- 200k Picky Tracks
- Fitted parameters
- All the hits – to project back upstream
- Waveforms from 4 TOF PMTs

Where is the beam on the upstream scintillator?

Scintillator is a diamond – this is the projected mage of hits in 1st WCs

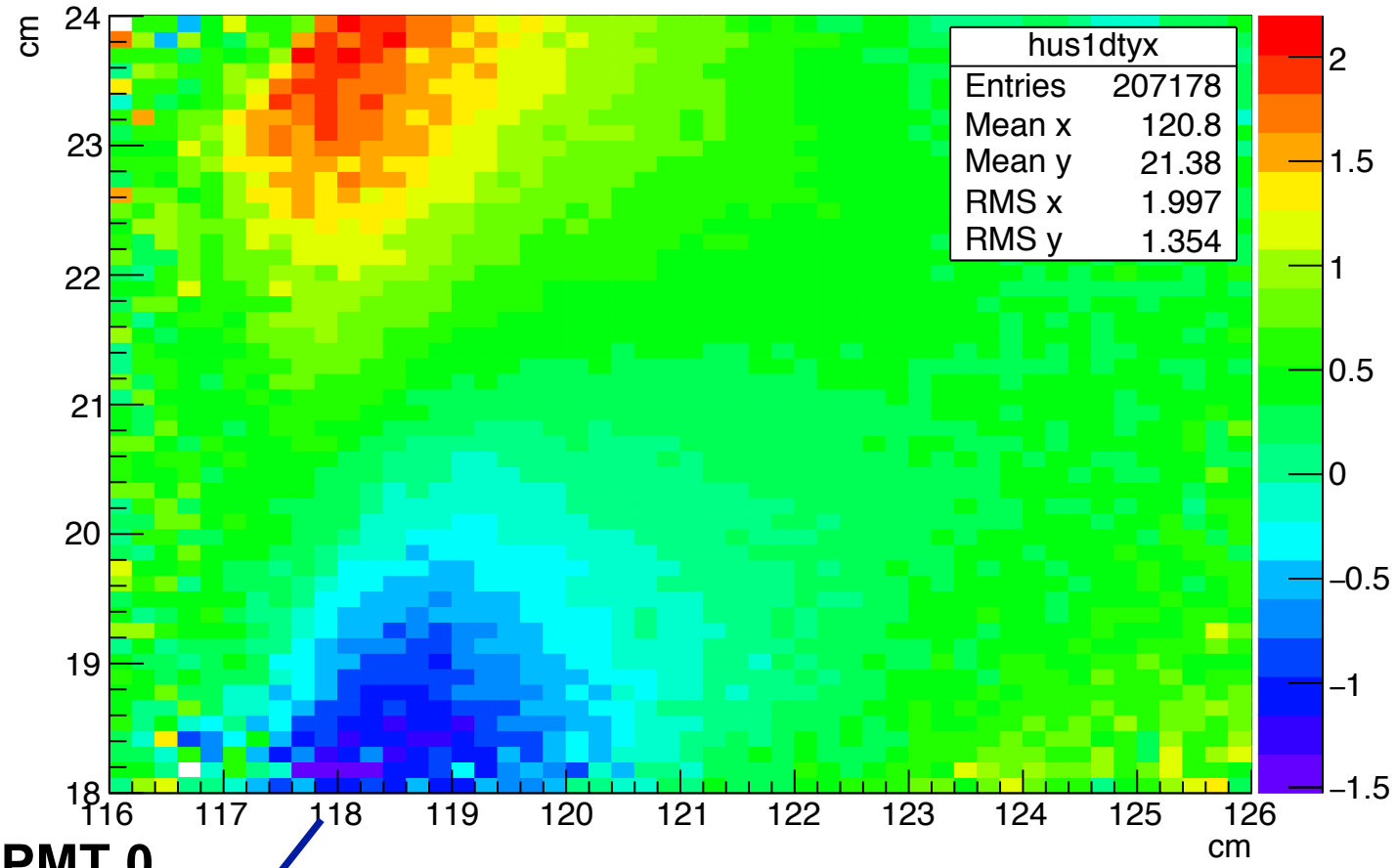


It's round and centered

How does dt(PMT1-PMT0) vary over the upstream scintillator?

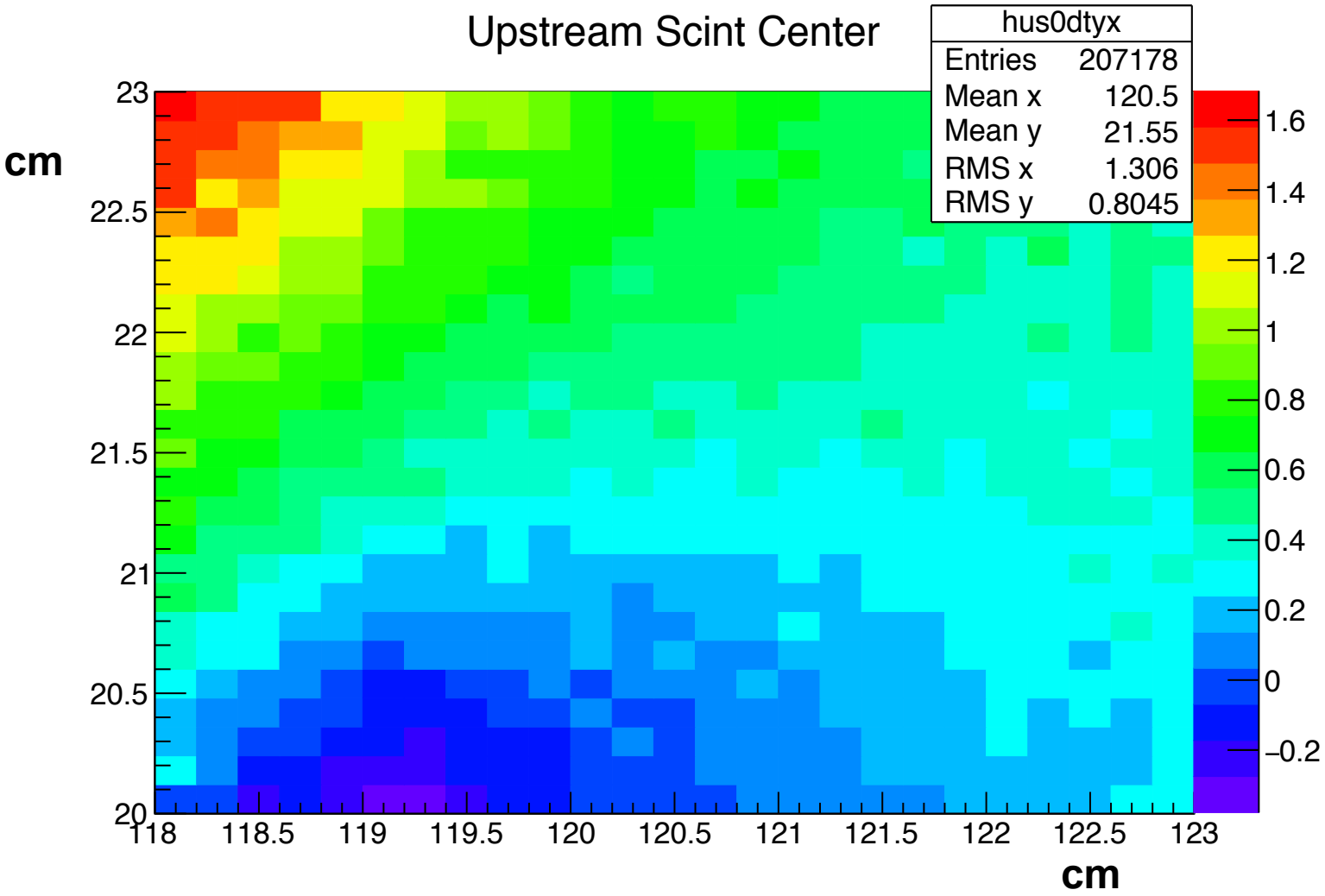
To PMT 1

Upstream Scintillator: Broad View

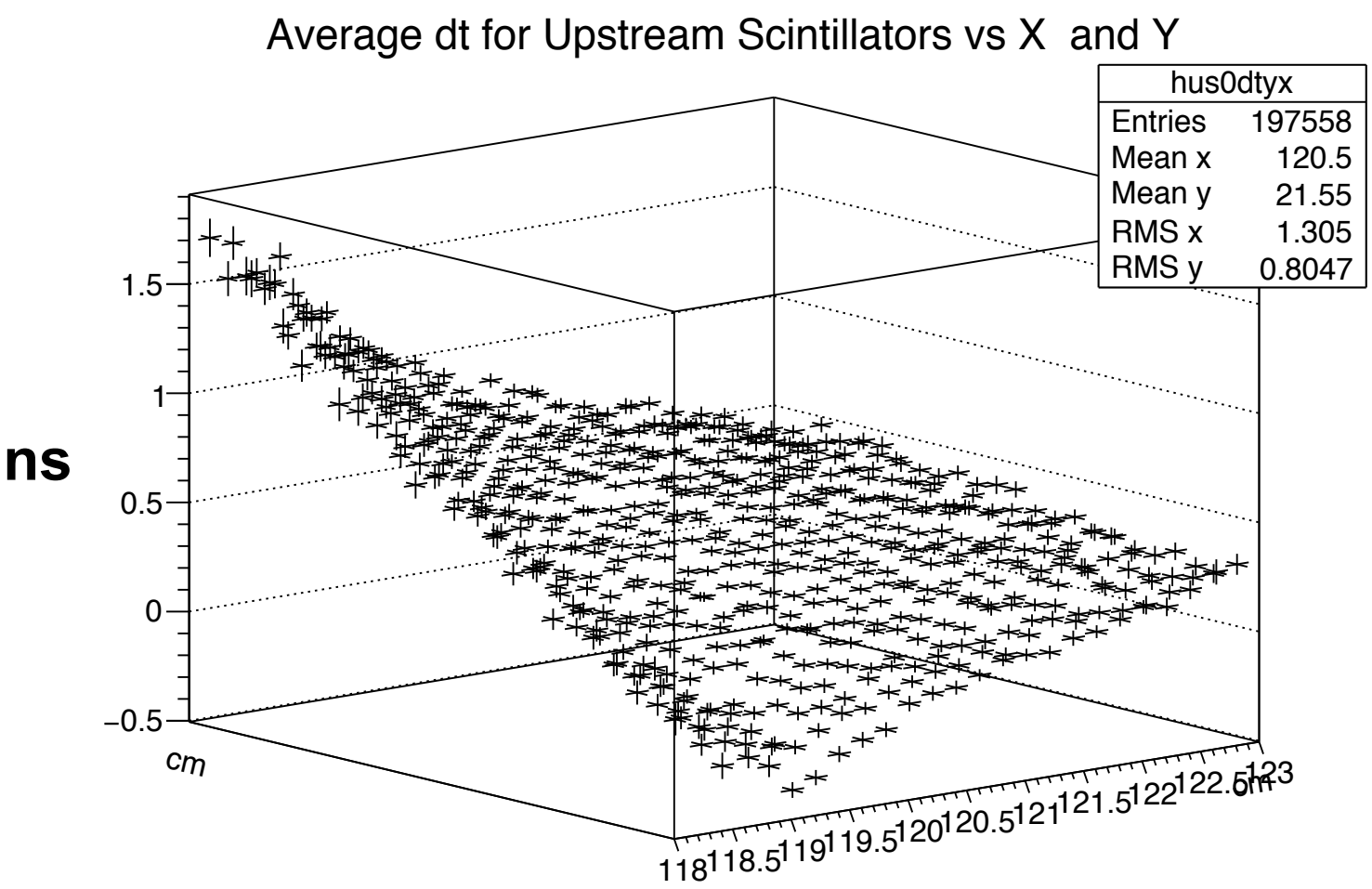


To PMT 0

How does dt (PMT1-PMT0) vary over the scintillator?

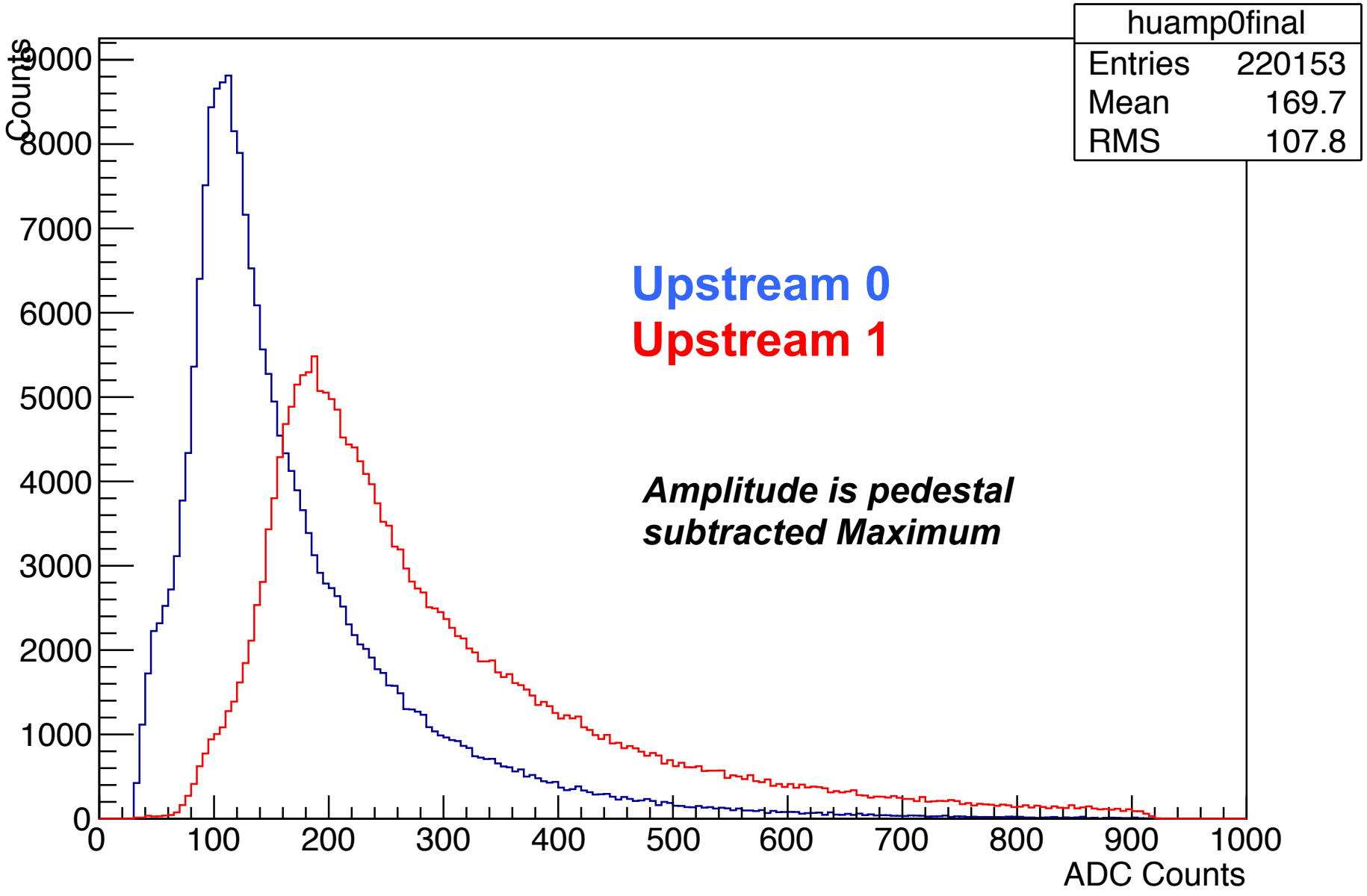


Halcyon Days of 3D rotation



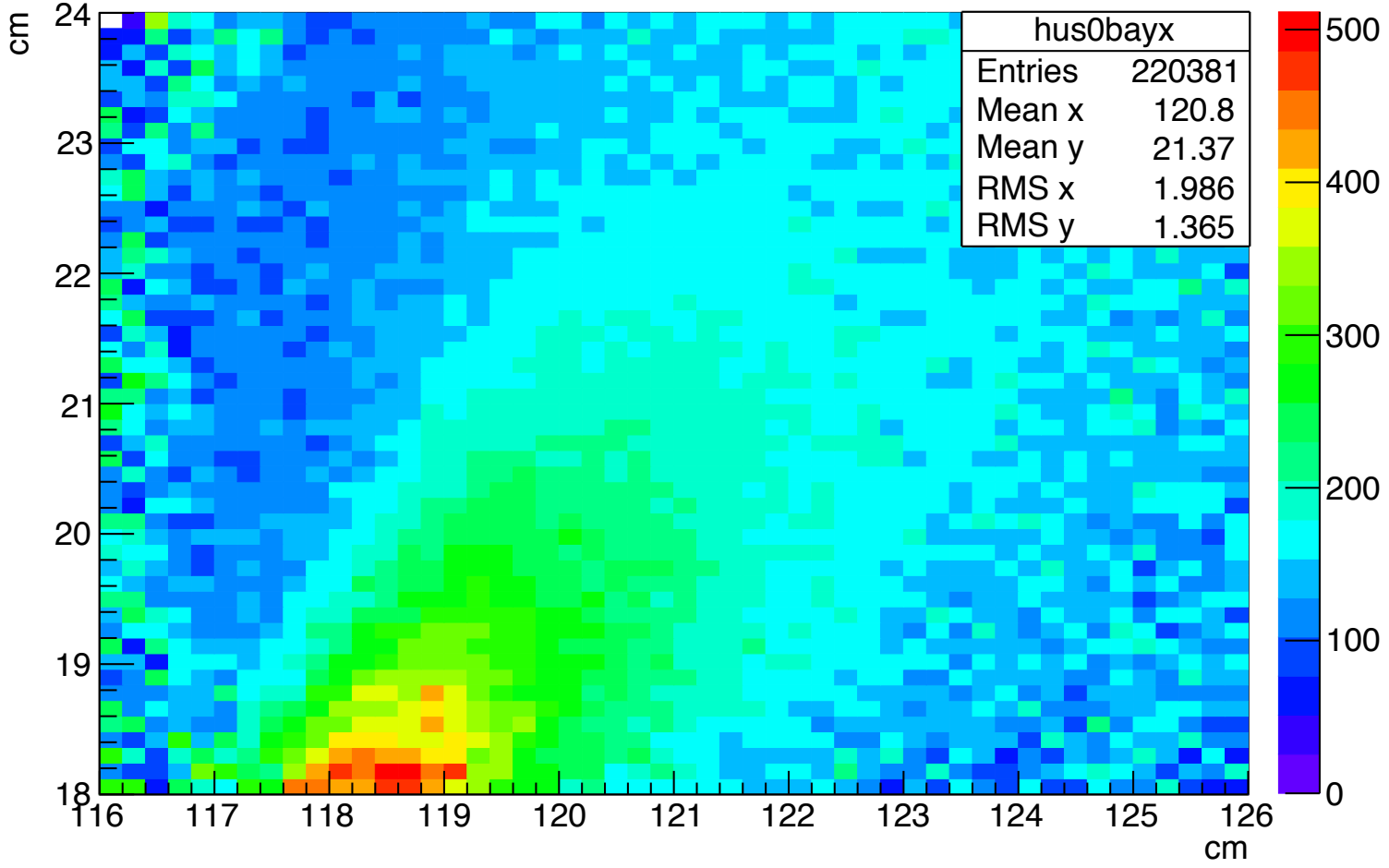
Central Region of Scintillator

Upstream Scintillators: Amplitude

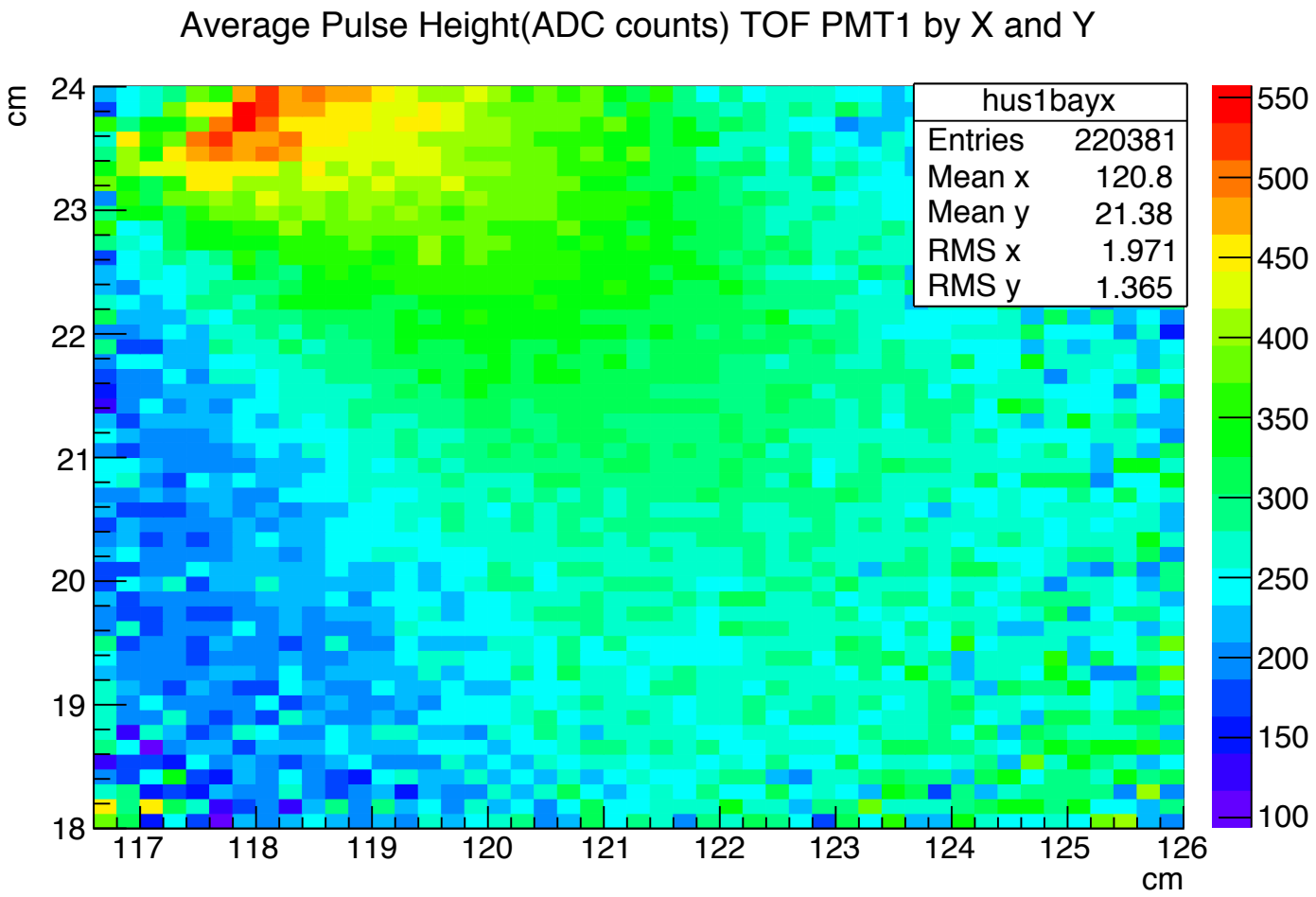


How does the pulse amplitude vary?

Average Pulse Height(ADC counts) TOF PMT0 by X and Y



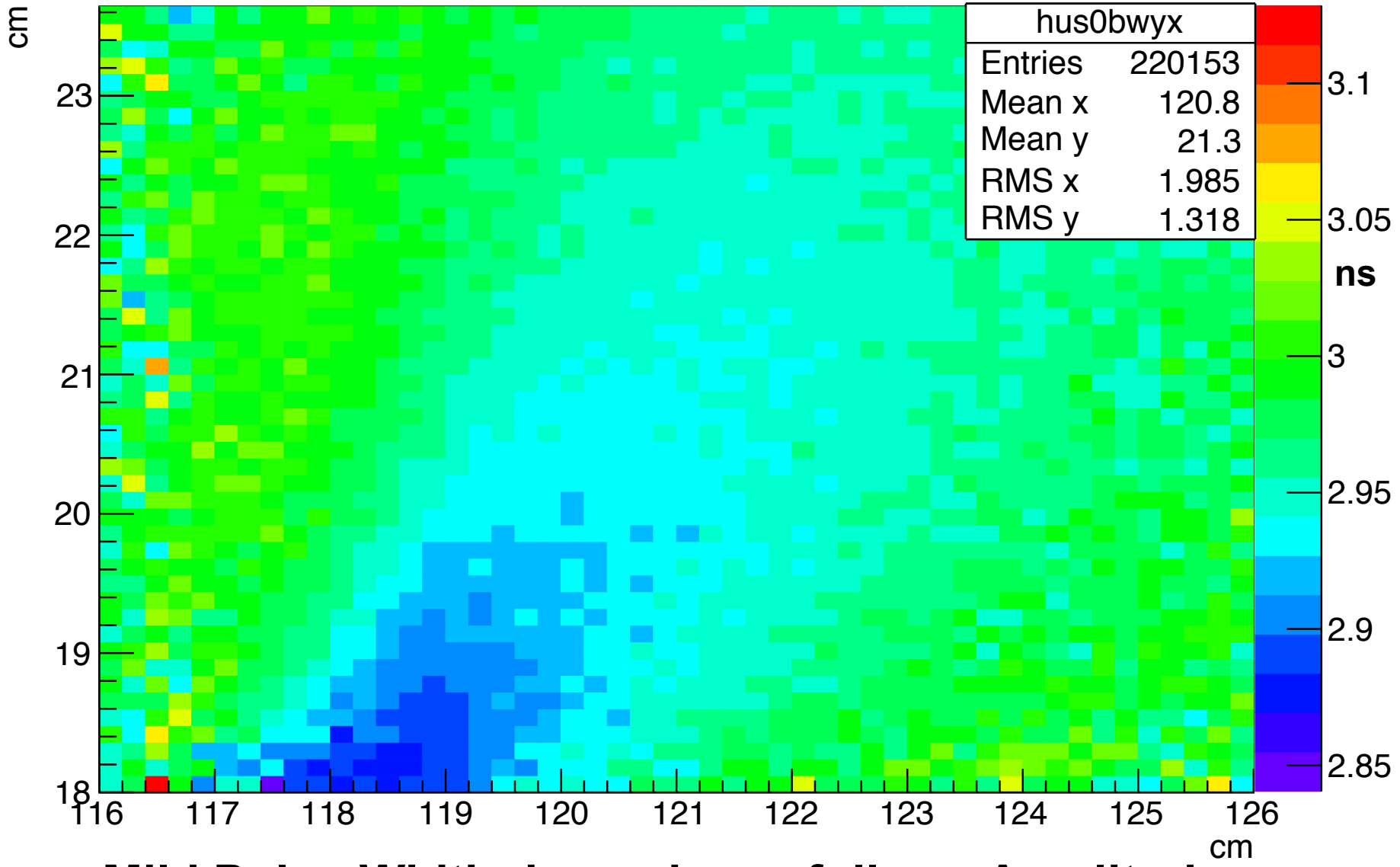
How about pulse amplitude in PMT1?



Pulse height variation in PMTs

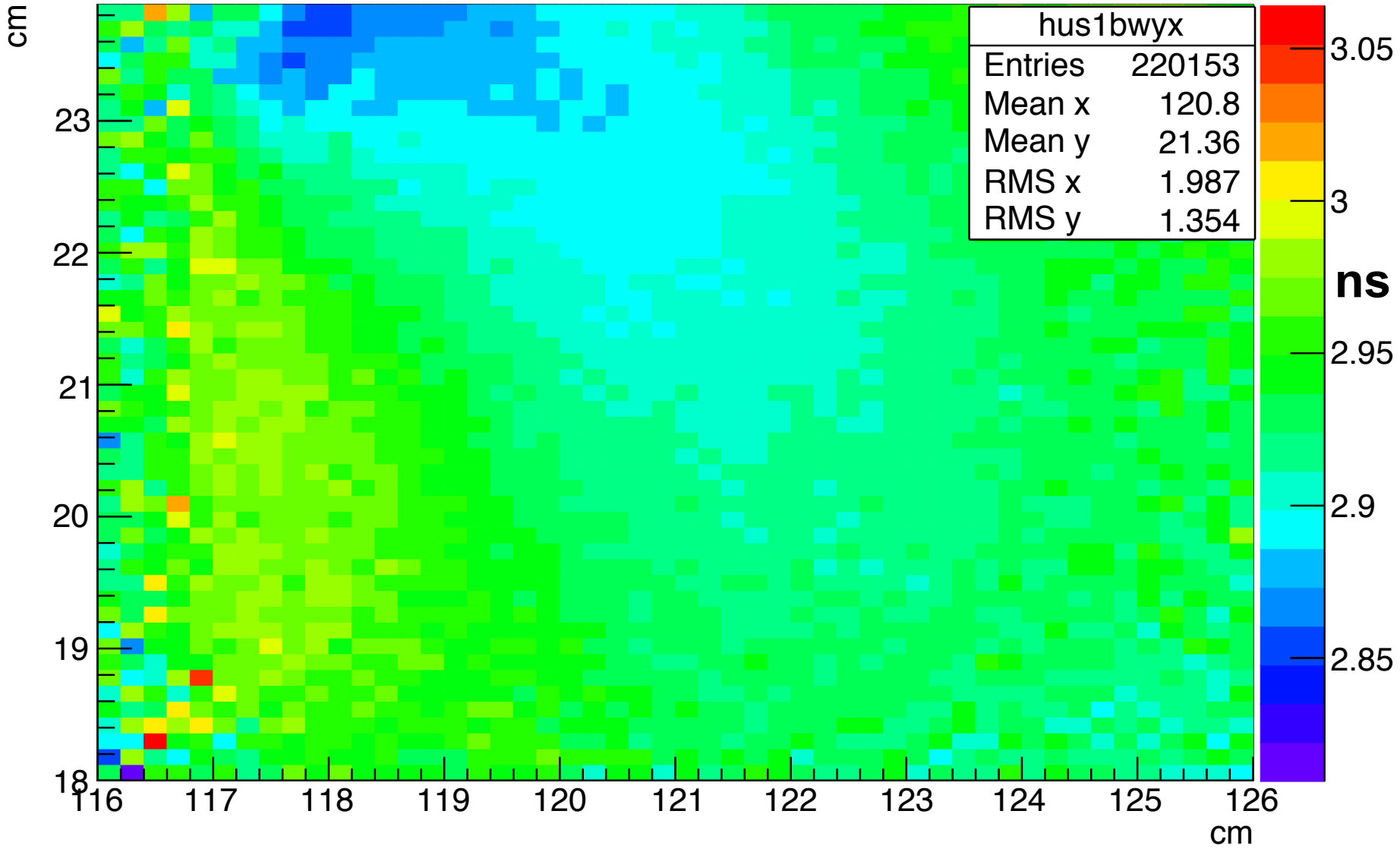
- Range is pretty impressive: factor 5 or so for both PMTS
- Variation is highly directional, corresponding to angular acceptance of PMTs

Upstream Counter 0: Pulse Width in ns by XY



Mild Pulse-Width dependence follows Amplitude

Upstream Counter 1: Pulse Width in ns by XY



Again, width tracks energy (modestly)

Why the range in delta-t and what can we do about it?

- Large range in delta-t probably arises because of qualitatively different optical paths between scintillation site and PMTs (line of sight vs. reflections). A general correction will probably require real work.
- At the cost of statistical power, we can probably improve our timing resolution just by cutting on where tracks strike the scintillator.

… Continued

- Use average of PMT pulse times
- Tune beam, place counters appropriately (not bad as is)
- Read out all four sides of scintillator
- Further study: establish simple optical properties, exact locations